System Operational Effectiveness:

Assessment of "Cause-And-Effect" Dependency between System Design & Support

Dr. Dinesh Verma
Associate Dean and Professor
Stevens Institute of Technology, Hoboken, New Jersey

Mr. Cliff Geiger
President
Unified Industries, Springfield, Virginia

Mr. Louis Kratz
ADUSD, Logistics Programs and Plans
Office of Secretary of Defense, Pentagon

NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION

Systems and Supportability Engineering Symposium
October, Dallas, Texas

Presentation Outline

Why?

- **The System Integration Business Model and Performance Based Contracting**

What?

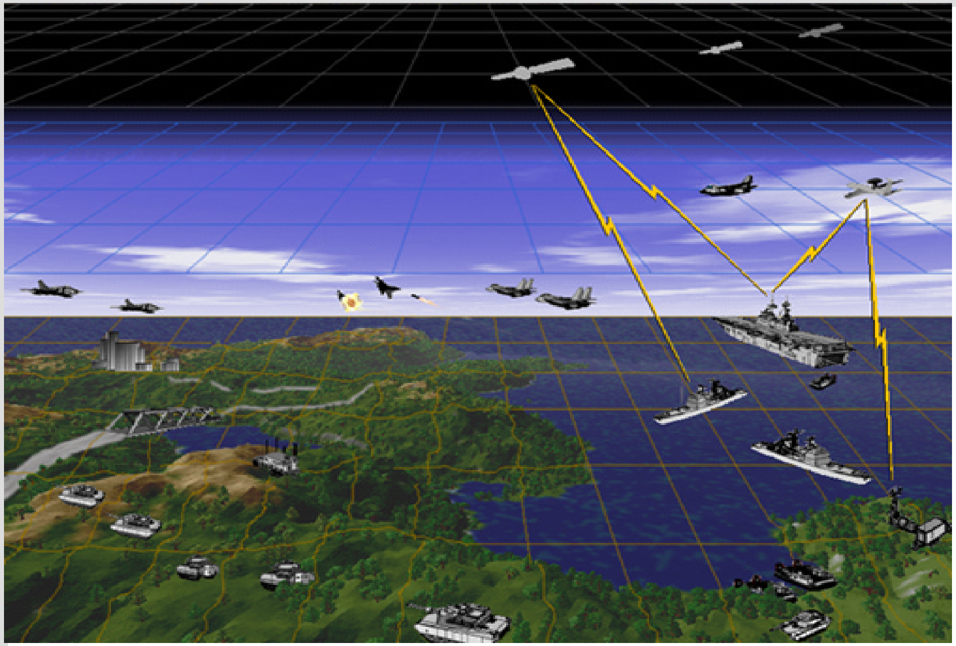
- **Suggested Definition of an Approach: System Operational Effectiveness Framework**

How?

- **Suggested Methods and Metrics: Trade-offs Between Performance and Cost; Dependency between Design and Support**

Systems Integration

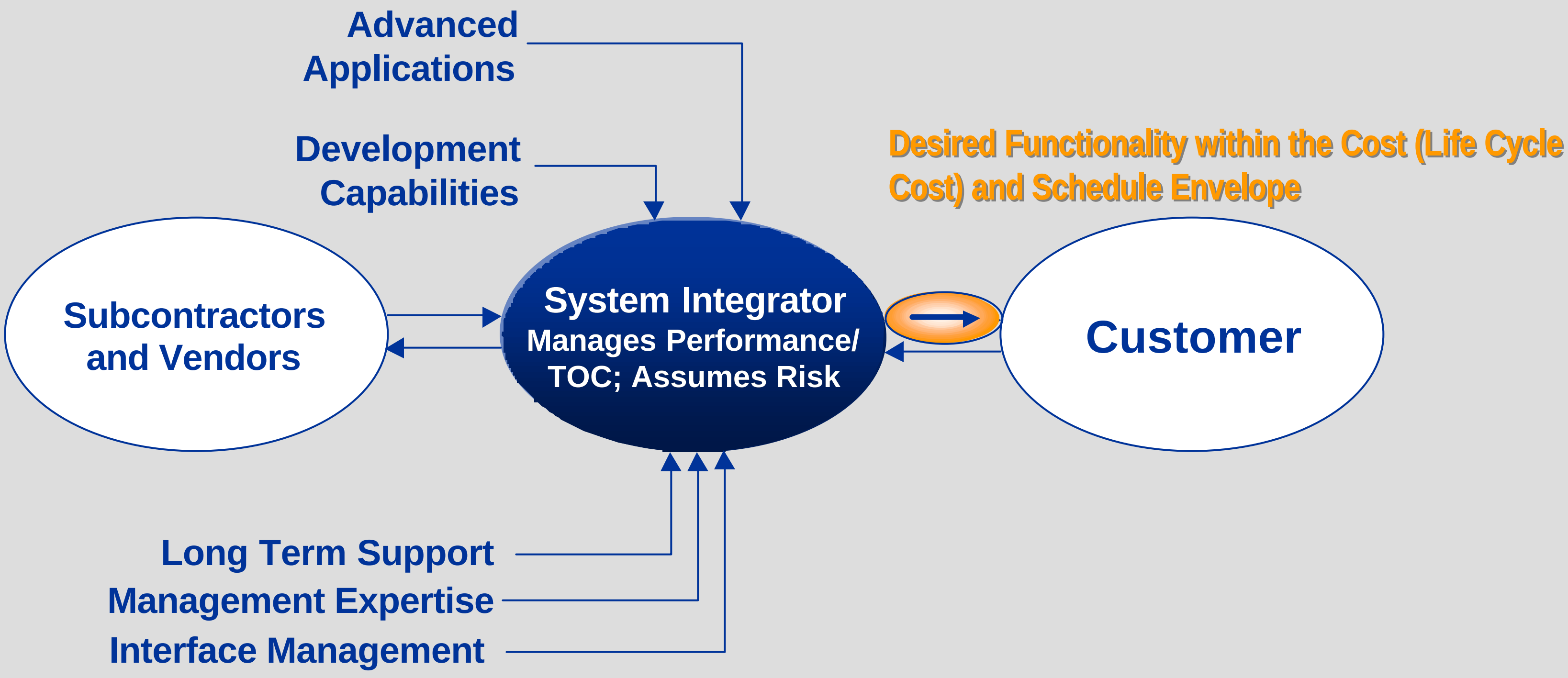
- **Definition**
  - **From Webster's Revised Unabridged Dictionary (1913) (web1913)**
    - **Integration \In`te*gra"tion\, n.[L.** integratio **a** renewing, restoring**:** cf. F. int[`e]gration.] **1. The act or process of making whole or entire.**



- **Definition**
  - **Systems Integration Is an "Entire View" of Missions and Operational Environments Achieved By Combining Capabilities of Platforms, Systems, Operators, & Support to Maximize Performance**
  - **Role of a System Integrator: Evolves from Providing Products, Systems & System Elements… to Providing Functionality or Solutions**
  - **Role of a Customer: Evolves into the concept of Performance Based Contracting - from Contracting for Products, Systems, & System Elements… to Contracting for a Functionality or a Capability**

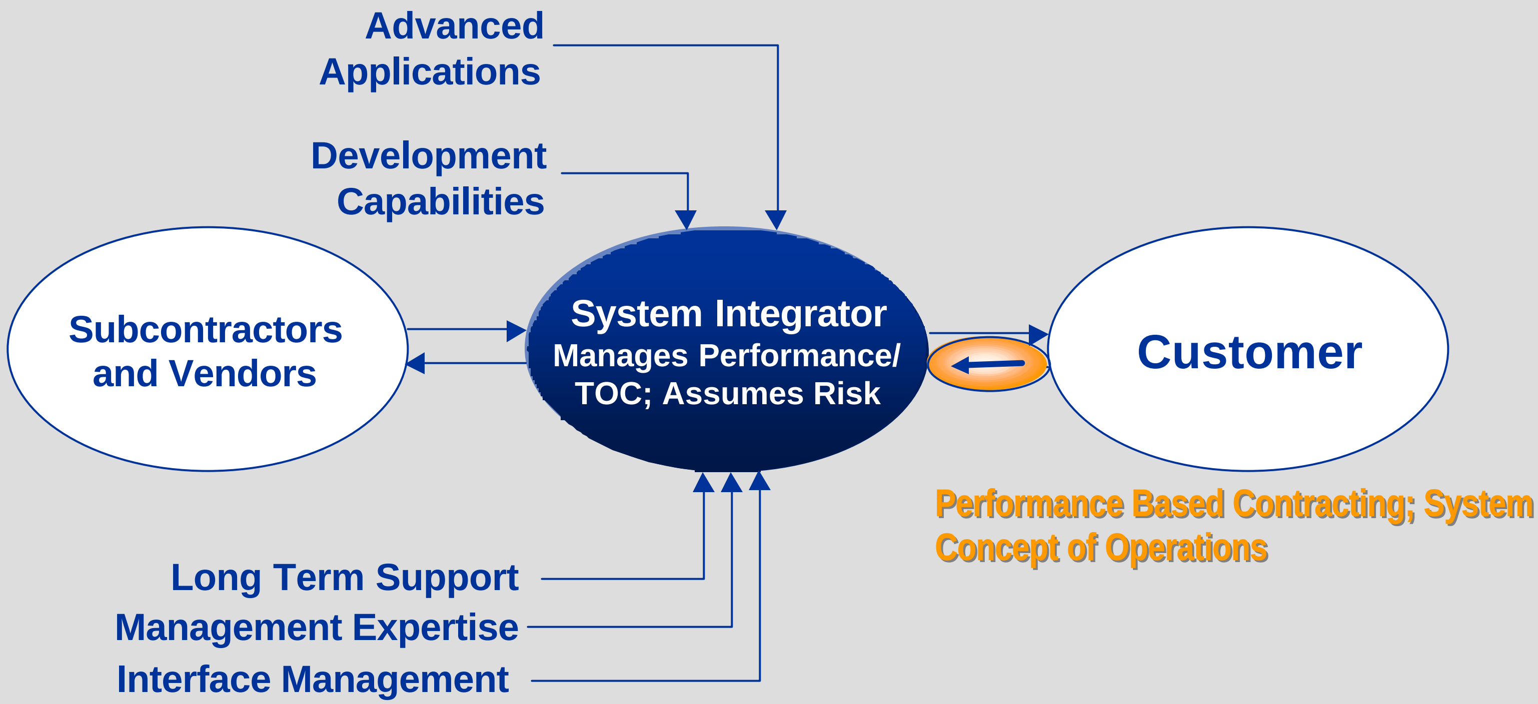
Systems Integration

- **The System Integrator**
  - Manages System Effectiveness Through:
    - System Performance - Guaranteed End-To-End Performance
    - Total Ownership Cost (TOC) - Guaranteed Affordability
  - Assumes Cost, Schedule, and Performance Risks

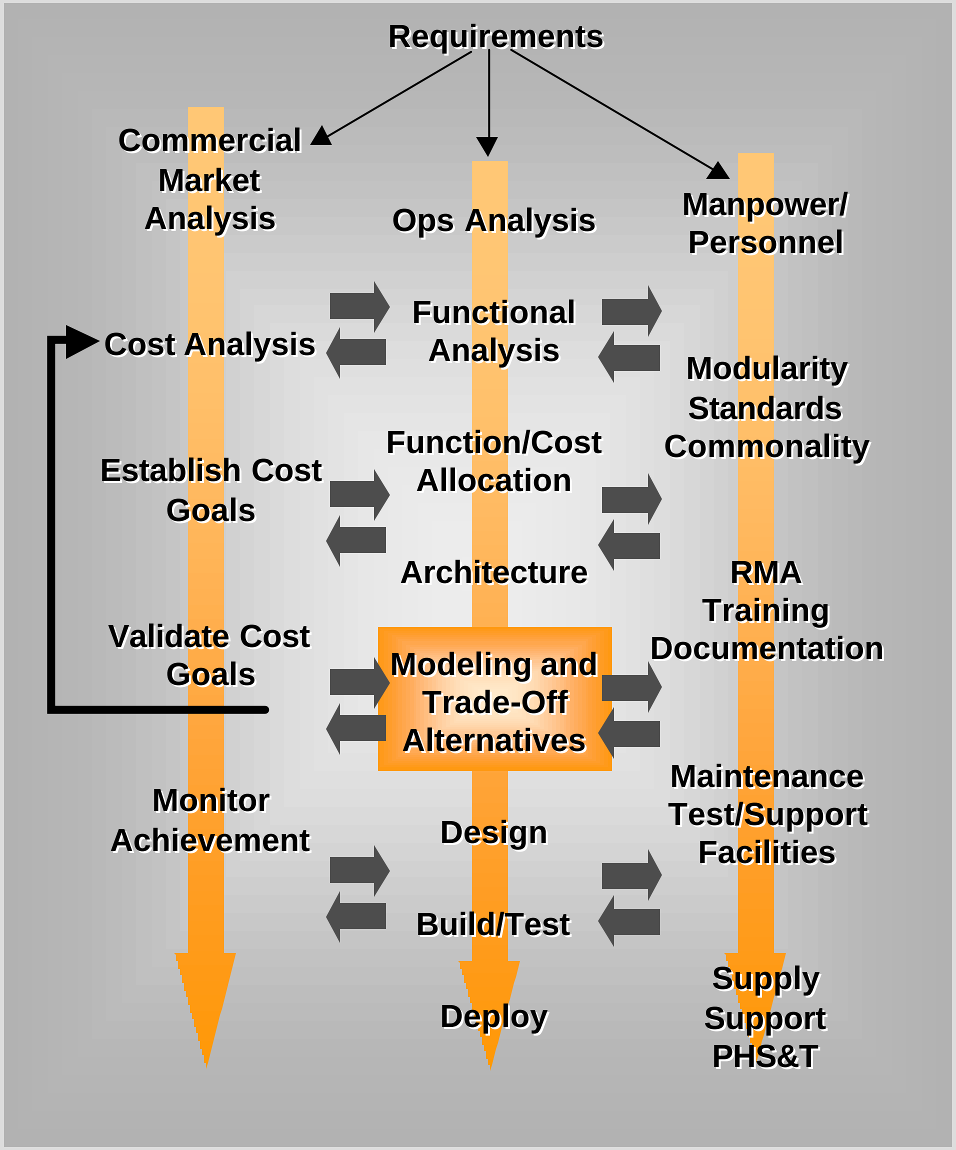


Systems Integration

- **The System Integrator**
  - **Manages System Effectiveness Through:**
    - **System Performance - Guaranteed End-To-End Performance**
    - **Total Ownership Cost (TOC) - Guaranteed Affordability**
  - **Assumes Cost, Schedule, and Performance Risks**



Systems Engineering - A Definition

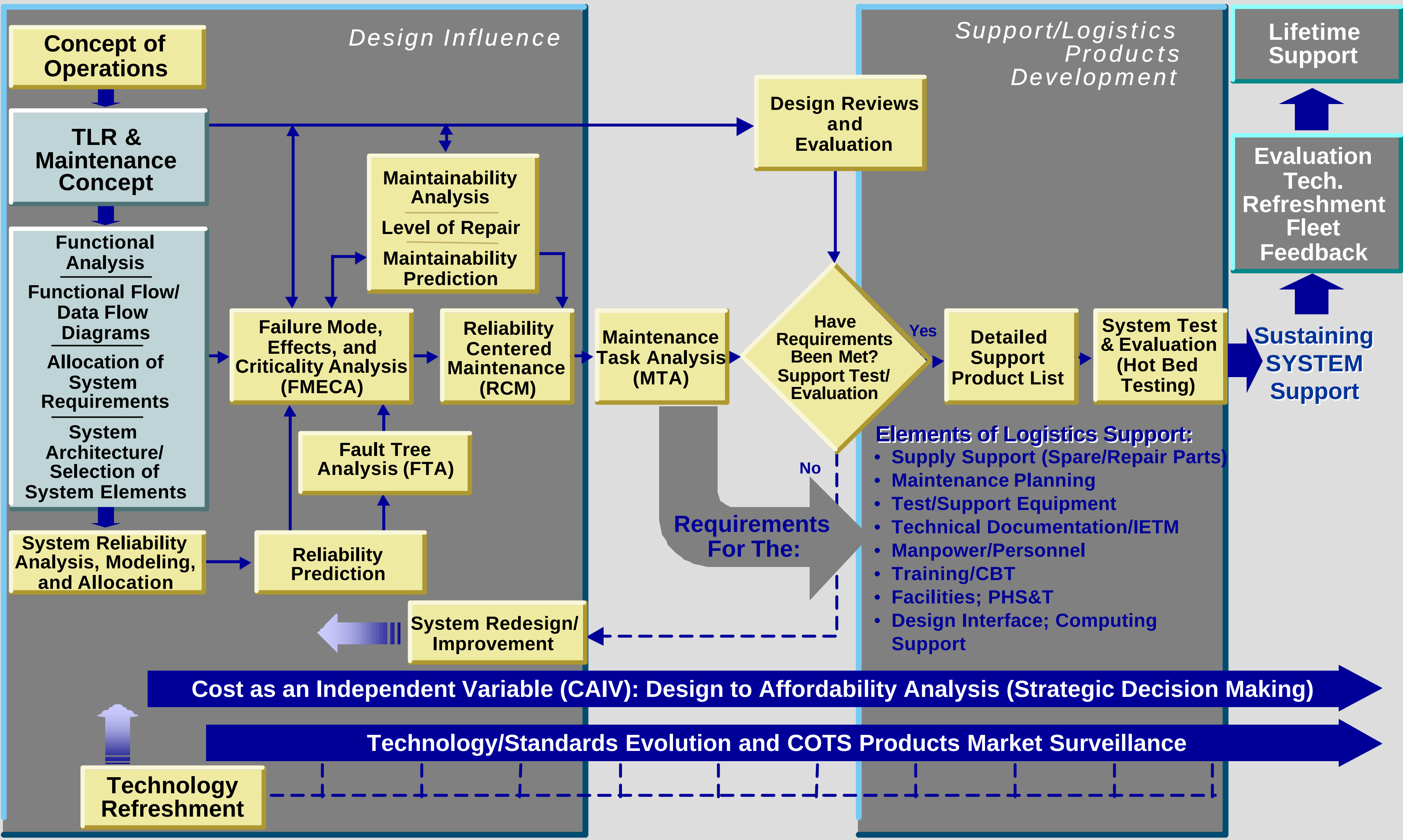


...translation of a need/deficiency into a system architecture through the iterative process of functional analysis, allocation, implementation, optimization, test, and evaluation;

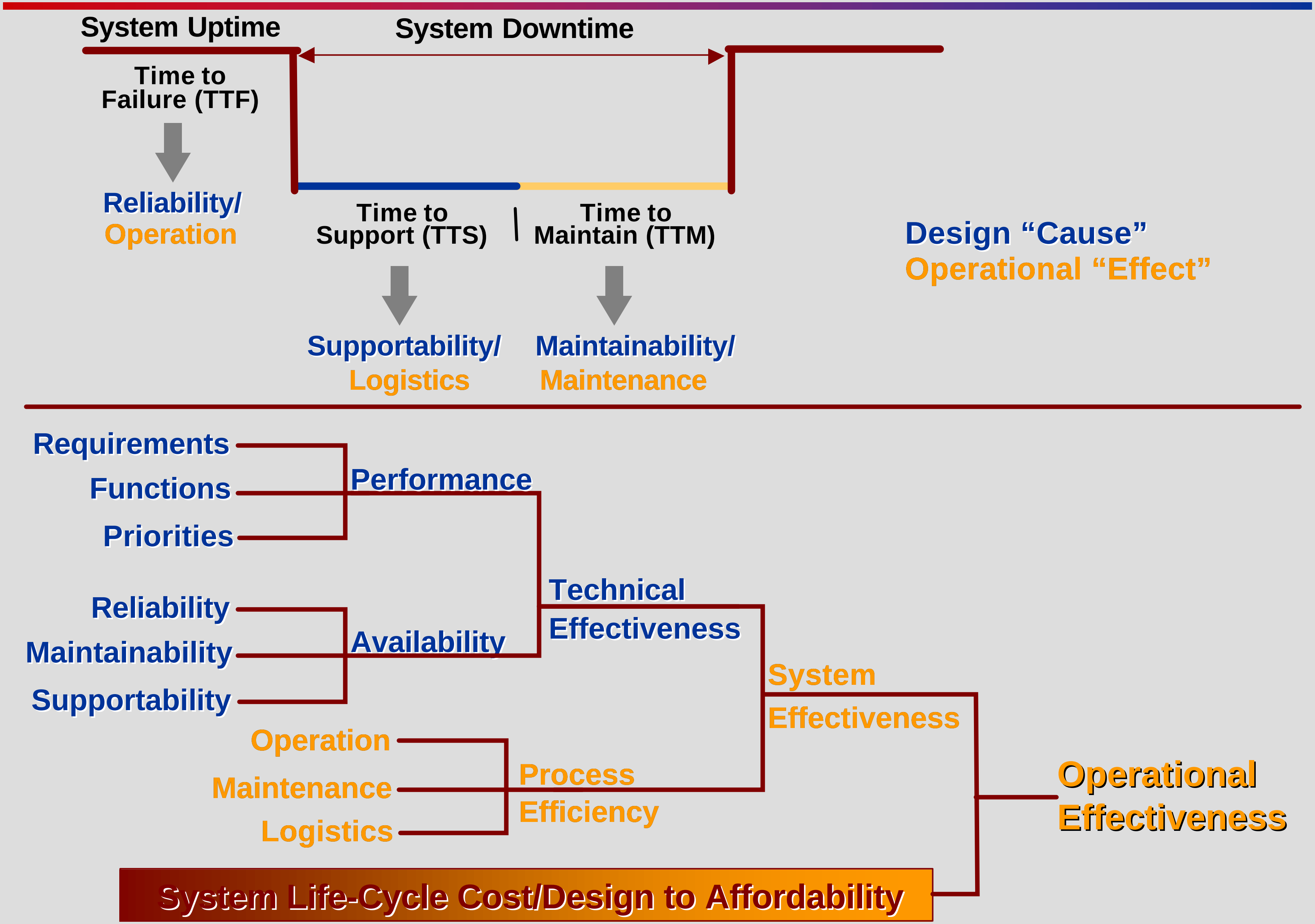
...incorporation of technical parameters to assure compatibility between physical & functional interfaces, hardware & software interfaces, in a manner that optimizes system definition and design; and

...integration of performance, manufacturing, reliability, maintainability, supportability, global flexibility, scaleability, upgradeability and other specialties into the overall engineering effort.

Systems and Supportability Engineering



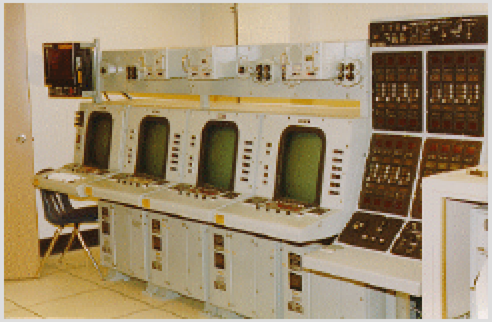
System Operational Effectiveness



System Operational Effectiveness

System Architectural Evolution

Past



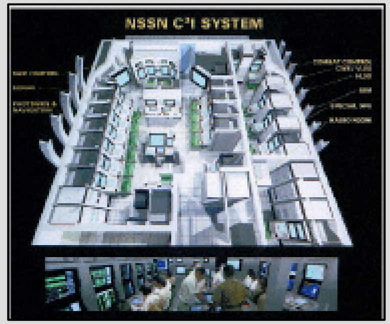
- Unique Hardware and Software for Computing Infrastructure
- Closed/Proprietary Architecture/ Interfaces
- Mission Capabilities Created By the Combination of Unique Software and Hardware

Unique Software

Tightly Linked Proprietary Interface

Unique Hardware

Present



75% COTS

5:1 Reduction in Cost

100X Increase in Throughput

- Commercially Available Technologies for Computing Infrastructure
- Open Architecture Using Commercial Standards for Interfaces
- Mission Capabilities Created By Reliable, Dependable, Durable Software Applications

Application Software

Application Software

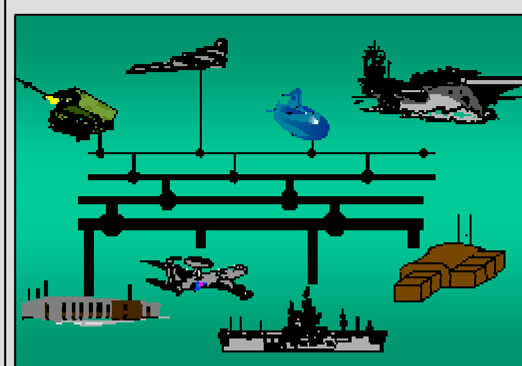
Standard Application Program Interface Results in New System Partitioning

Unique Sensor & Weapon Interfaces

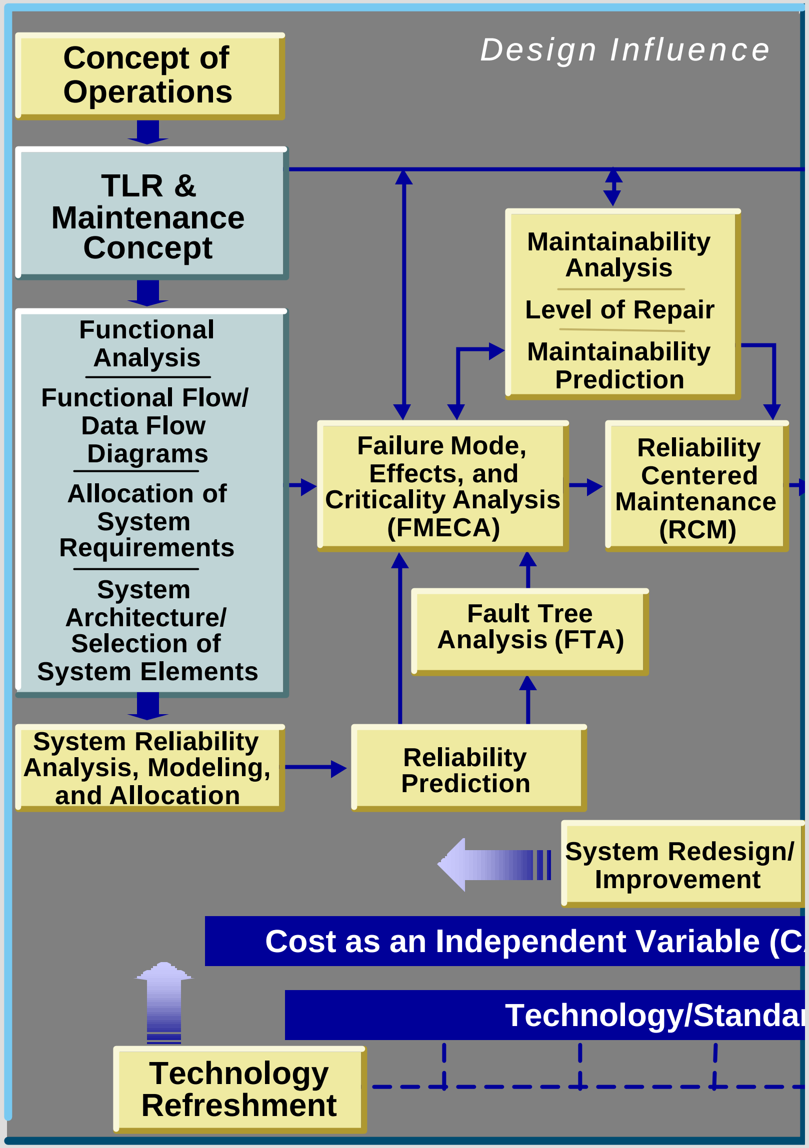
COTS Based Hardware and Software Computing Infrastructure

Future

- Extend Open Standards to Focus on Interoperability (Net-Centric)
- Utilize High Throughput of Commercial Technologies to Address Automation and Supportability
- “Smart” Software



Systems and Supportability Engineering



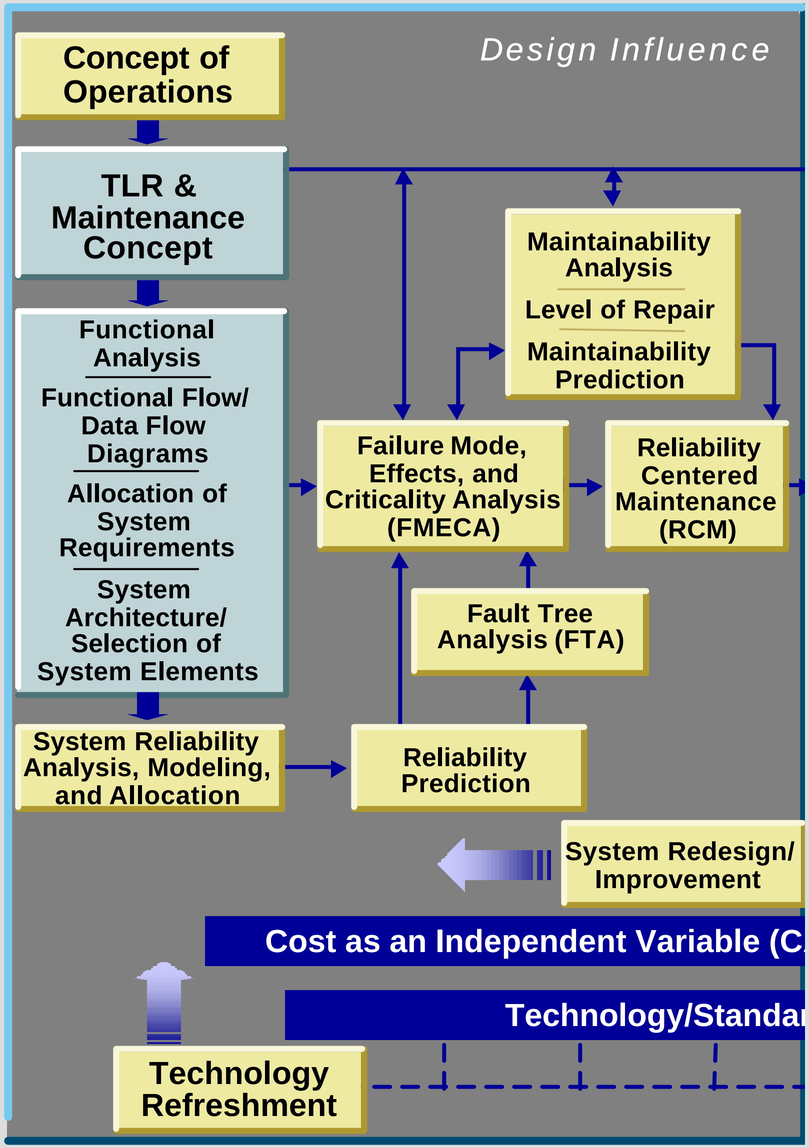
Reliability

Maintainability

Supportability

- Redundancy
- Reconfigurability
- De-Rating
- System Criticality Assessment
  - Single Points of Failure
  - Degraded Modes of Operation
- Metrics
- Tools

Systems and Supportability Engineering



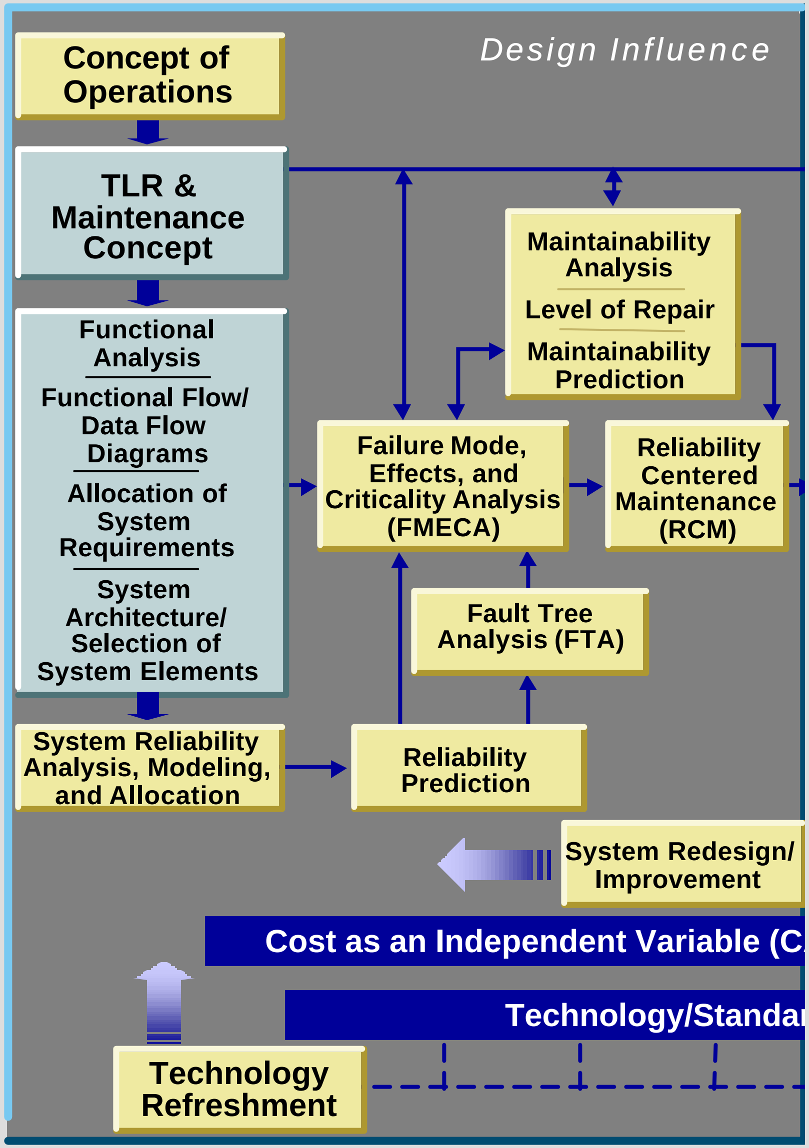
Reliability

Maintainability

Supportability

- Maintenance Concept
- Accessibility
- Performance Monitoring and Fault Localization
  - Built-In Test Coverage
  - System Modularity/De-Coupling
  - Condition and Usage Monitoring
- Metrics
- Tools

Systems and Supportability Engineering



Reliability

Maintainability

Supportability

- System Commonality
  - Physical Commonality
  - Operational Commonality/HMI Standardization
  - Functional Commonality
- Standard Parts
- Standard Tools/Equipment
- Intuitive User Interface
- COTS/GOTS Selection and Assessment
  - Open/Popular System Standards Compliance
  - Multiple Vendors
  - Technology Maturity
- Metrics
- Tools

System Architecture "Goodness"

Commonality

- Physical Commonality (Within the system)
  - HW Commonality
    - Number of Unique LRUs
    - Number of Unique Fasteners
    - Number of Unique Cables
    - Number of Unique Standards Implemented
  - SW Commonality
    - Number of Unique SW Packages Implemented
    - Number of Languages
    - Number of Compilers
    - Average Number of SW Instantiations
    - Number of Unique Standards Implemented
- Physical Familiarity (From other systems)
    - % Vendors Known
    - % Subcontractors Known
    - % HW Technology Known
    - % SW Technology Known
- Operational Commonality
    - % of Operational Functions Automated
    - Number of Unique Skill Codes Required
    - Estimated Operational Training Time - Initial
    - Estimated Operational Training Time - Refresh from Previous System
    - Estimated Maintenance Training Time - Initial
    - Estimated Maintenance Training Time - Refresh from Previous System

Modularity

- Physical Modularity
  - Ease of system element upgrade
    - Lines of modified code
    - Amount of labour hours for system rework
  - Ease of operating system upgrade
    - Lines of modified code
    - Amount of labour hours for system rework
- Functional Modularity
  - Ease of adding new functionality
    - Lines of modified code
    - Amount of labour hours for system rework
  - Ease of upgrade existing functionality
    - Lines of modified code
    - Amount of labour hours for system rework
- Orthogonality
  - Are functional requirements fragmented across multiple processing elements and interfaces?
  - Are there throughput requirements across interfaces?
  - Are common specifications identified?
- Abstraction
  - Does the system architecture provide and option for information hiding?
- Interfaces
  - # of Unique Interfaces per System Element
  - # of Different Networking Protocols
  - Explicit versus Implicit Interfaces
    - Does the architecture involve implicit interfaces?
  - # of Cables in the System

Standards Based

- Open Systems Orientation
  - Interface Standards
    - # of Interface Standards/# of Interfaces
    - Multiple Vendors (Greater than 5) Exist for Products Based on Standards
    - Multiple Business Domains Apply/Use Standard (Aerospace, Medical, Telecommunications)
    - Standard Maturity
  - Hardware Standards
    - # of Form Factors/# of LRUs
    - Multiple Vendors (Greater than 5) Exist for Products Based on Standards
    - Multiple Business Domains Apply/Use Standard (Aerospace, Medical, Telecommunications)
    - Standard Maturity
  - Software Standards
    - # of proprietary & unique operating systems
    - # of non-std databases
    - # of proprietary middle-ware
    - # of non-std languages
- Consistency Orientation
    - Common Guidelines for Implementing Diagnostics and Performance Monitoring and Fault Localisation
    - Common Guidelines for Implementing OMI

RMT

- Reliability
  - Fault Tolerance
    - % of mission critical functions with single points of failure
    - % of safety critical functions with single points of failure
  - Critical Points of Delicateness (System Loading)
    - % Processor Loading
    - % Memory Loading
      - How critical is this?
    - % Network Loading
      - How critical is this?
- Maintainability
  - Expected MTTR
  - Maximum Fault Group Size
  - Is system operational under maintenance?
  - Accessibility
    - Are there space restrictions?
    - Are there special tool requirements?
    - Are there special skills requirements?
- Testability
  - # of LRUs covered by BIT (BIT Coverage)
  - Reproducibility of Errors
    - Logging/Recording Capability
    - Create system state at time of system failure?
  - Online Testing
    - Is system operational during external testing?
    - Ease of access to external testpoints?
  - Automated Input/Stimulation Insertion

A Non-Response from Academia

- **In a 1990 Survey (Conducted by Virginia Tech):**
  - 73 programs (Universities) were identified as offering a degree in Systems Engineering, however a majority of these programs are aligned with a functional area (Industrial, Information, Mechanical)
  - Only 8 programs appeared to offer an option for interdisciplinary Systems Engineering
    - Of these 8, a subset focused on System Design but none offered a focus on System Reliability, Maintainability, and Supportability
    - Only 2 of these options had electives on subjects related to logistics
- **In a 1998 Survey (Conducted by University of Virginia):**
  - 23 programs offering Systems Engineering degrees were identified, however a majority of these programs are traditional industrial engineering programs
  - Only 7 programs focused on a system analysis and design view

Conclusions

- The desire and the lexicon has supported integrating support and logistics issues in the systems engineering process for decades.
  - The current emphasis on COTS-based architectures, system affordability, and network centric warfare mandates it!
- Accordingly it is essential to clear the haze surrounding the domain and scope of supportability and logistics
  - This is essential to translating the rhetoric related to CAIV and Performance Based Contracting into reality
- Understanding the domain and scope of supportability and logistics facilitates leveraging the intuitive “cause and effect” relationship between system design and system support…
and ultimately system affordability.